AIRCRAFT INFRASOUND
THE ESSENTIAL CAUSE OF DVT?

Analysis of published scientific and medical research suggests that infrasound from engine vibrations may be responsible for traveller's deep vein thrombosis.

by David Collier, BSc, DCH
© 2002

GPO Box 1755
Canberra, ACT 2600
Australia
Email: dc888@tpg.com.au

SIZE OF THE PROBLEM

Exposure to infrasound generated by jet engines is proposed as the essential cause of deep vein thrombosis (DVT) syndrome in airline passengers, temporal lobe atrophy in airline flight attendants, and air rage. According to the website http://www.aviation-health.org, of the 54 million passengers carried by European airlines on long-haul trips for an average of 9.4 hours, one million passengers, or around 5%, suffer from air-related DVT. On short-haul trips of 3–4 hours, it is 1–2 per cent. The UK House of Lords inquiry into this syndrome was not impressed with the evidence given by the owner of this website (which has nothing on infrasound), but the fact remains that these particular figures are consistent with those from other sources. The UK lobby group Victims of Air-Related DVT Association (VARDA) is linked to this website.

The Airhealth website, http://www.airhealth.org, has collated 21 medical reports leading to a conservative estimate of one million airline passengers diagnosed and treated in the USA each year, with 100,000 fatalities. Combining the European and American figures, we are likely to have greatly in excess of 100,000 fatalities per annum. Simple addition is not valid because many flights are between USA and Europe, hence shared by the two groups quoted. There are, of course, other parts of the world covered by airlines which would also add to these figures, so an overall world figure of 200,000 DVT fatalities per annum is possible. These are significant numbers which justify the attention now being given to this issue, and which fly in the face (*sic*) of those who suggest that the DVT risk is small. A present "failure to screen, assess, diagnose and/or prevent with pharmacological intervention the growing number of patients who are at risk for venous thromboembolism (VTE)" is admitted in Poponick and Bosker (2002). VTE includes DVT and pulmonary embolism (PE).

In a recent trial of 116 people, Scurr et al. (2001) showed that around 10% of long-haul (median 24 hours) passengers older than 50, but *selected to exclude other known risk factors*, developed "symptomless" DVT (small blood clots) after one return flight, returning to the UK within six weeks. This appears to be a significant finding (the general population is probably more at risk, compared with this specially selected sample), but it has not yet had an impact on the mind of the travelling public. These smaller blood clots are also capable of moving to the lungs, sometimes with fatal results. In this trial, all positive cases were treated with heparin and referred to their GPs.

There are two class-actions in progress: one involving Collins Solicitors, working with VARDA in the UK on a A$55 million case against several airlines, alleging that the airlines did not warn passengers of the risks of developing DVT; the other involving Slater & Gordon in Australia, suing QANTAS, BA, KLM and the Australian air safety body CASA on the same basis, as at July 2001.

The website http://www.flyana.com *inter alia* provides professional insight into how airline passenger health has been compromised by commercial or economic considerations in recent years.

STUDIES IN PROGRESS

The BEST (Business class vs Economy Syndrome as a cause of Thrombosis) study was undertaken between 9 April and 9 May 2002, and involving Dr Alberto Smith of King's College, London, the University of Witwatersrand in South Africa and South

African Airways. It aimed at including 1,000 passengers and reporting before the end of 2002 (email best-study@kcl.ac.uk).

The Australian Department of Health is said to be examining 10,000 medical records in collaboration with the University of Western Australia and the Australian Department of Immigration and Multicultural Affairs. Preliminary results were expected to be available by August 2002. This was reported in the *Times* of London on 4 April 2002; perhaps this is the "travel" study referred to in Anon. (2002). This relatively inexpensive study has evidently taken the place of what was to be the world's biggest (three-year, A$1.7 million) study starting in 2001, involving Dr Ross Baker of the Australasian Society of Thrombosis and Hemostasis (ASTH) and Dr Paul Bates of the School of Aviation Medicine at Griffith University in Queensland. It seems there was surprise and disappointment amongst the 35-strong research team when the Deputy Prime Minister (i.e., the Transport Minister) chose not to fund this previously well-advertised Australian study. One doctor commented in the media that the smaller study was "useless".

MEDICAL EVIDENCE

According to James H. Morrissey, Professor of Biochemistry at the University of Illinois College of Medicine: "The causes of DVT in general, not to mention specific types, are not well understood. Repetitive prolonged vibration is a well-documented risk factor for peripheral thrombotic disease" (personal communication, 27 July 2001).

Bendz et al. (1999) showed that an air pressure change from sea level to 2,000 metres over 5 to 10 minutes in a hypobaric chamber (designed to simulate what actually happens in an airplane after take-off) was associated with activation of the tissue factor pathway, which is primary in the blood clotting process. He attributed this to hypoxia, but did not exclude other possible mechanisms. However, he measured only a 5% decrease in oxygen saturation levels (from 98.4% to 93.4%) over two hours. Further, he found that factor VIIa activity increased most rapidly over the first 30 minutes of the experiment; blood samples were not taken at lesser intervals. It is suggested that physical (barometric or infrasonic) cellular trauma is actually responsible for these findings—something that most medical researchers, at least in the West, appear not to have considered.

There is evidence that infrasound can disrupt cellular organelles including the nucleus: e.g., Gabovich (1979); Nekhoroshev and Glinchikov (1992), who found irreversible damage to hepatocytes at 8 Hz and 16 Hz; and Silva et al. (1996). Stepanian et al. (2000) found changes in properties of water and a DNA solution exposed to vibration at specific frequencies of 4 Hz and 10 Hz, but not at higher frequencies. Low-frequency noise exposure can change epithelial histology in rats (personal communication with Alves-Pereira, 2002).

Populations living at high altitude are not hypoxic and do not have increased incidence of venous thromboembolism (VTE), according to Kesteven and Robinson (2000); therefore, a dynamic air pressure change appears to be what is important.

Cerebral thrombosis "at altitude" was discussed by Song et al. (1986) in the aviation medicine context. Thrombosis "at mountain altitudes" was reported by Cucinell and Pitts (1987) in the same context. Deep venous thrombosis (i.e., DVT syndrome) was reported "in the military pilot" by Steinhauser and Stewart (1989). There is an obvious linkage between these papers, including Bendz et al. (1999): they all involve a change to a lower air pressure, aircraft and blood coagulation. Only Bendz et al. seem to have realised and demonstrated that a relatively rapid change in air pressure, outside that which our species has generally experienced in biological evolution and outside that which can be realised through individual locomotion, is significant. Exposure to low-frequency noise/vibration was apparently not a factor in the Bendz et al. experiment, except in the barometric frequency range of infrasound, but it may well have been a factor in the other results reported.

There is an important, though it seems not well known, body of Eastern Bloc medical research supportive of the thesis that exposure to infrasound causes blood coagulation.

There is an important, though it seems not well known, body of Eastern Bloc medical research supportive of the thesis that exposure to infrasound *inter alia* causes blood coagulation: e.g., Mikhailova (1971); Polanowska and Cierniewski (1987); Serikova et al. (1977); Svidovyi et al. (1985); Tropnikova (1990); and Vasilev (1999). Polanowska mentions "intense infrasounds from arc furnaces"; serotonin levels mentioned in Tropnikova are widely accepted as related to cellular trauma; and changes in blood vessels as mentioned in Vasilev are one part of Virchow's triad of factors leading to blood coagulation. These papers were not available *in toto* and, as far as is known, have not been translated into English. Their titles and in some cases abstracts are at least highly suggestive, including that some of these countries are years ahead of the West in this area of (occupational) health and safety.

There are guidelines or regulations specific to occupational infrasound exposure in Denmark, Norway, Poland and Russia that are not referenced in this article.

VIBRO-ACOUSTIC DISEASE

Twenty years of research into vibro-acoustic disease (VAD)—coincidentally in aviation personnel—by Castelo Branco et al. (1999) has now defined a series of syndromes which include the cardiorespiratory system, neurological and psychological disorders including spontaneous rage reactions (hence "air rage") and immunological changes. This work defines VAD as the consequence of occupational exposure to high-amplitude, low-frequency noise for 10 years or more, although some symptoms are evident after one year. It has for the first time established the reality of insidious systemic extra-aural adverse health effects of exposure to low-frequency noise.

In further reference to "air rage", it is already known that infrasound can entrain brainwaves (which are in the infrasonic frequency range), as can strobe light and low-frequency electromagnetic radiation. We can now appreciate the wisdom in the old saying about what kind of noise annoys an oyster: the similar-sounding words "noise" and "annoys" are perhaps of common origin.

VAD represents a paradigm shift in our understanding, with immense social and economic implications touched on in Alves-Pereira and Castelo Branco (2000). All present noise legislation, except as mentioned above, erroneously assumes that noise only affects the ear. I quote from their paper: "All the above information must be made public. It is no longer acceptable that individuals have their lives destroyed because of excessive low frequency noise exposure" and "This raises the issue (of VAD) to the domain of Public Health issues".

In the 1980s, this Portuguese team studied blood coagulation parameters in aviation technicians and found hypercoagulability. More recently, a paper was presented by them at the Aerospace Medical Association 2000 Annual Meeting, demonstrating that "Hypercoagulability exists in airline pilots after a rest period, suggesting that flight fatigue includes this state of the blood. Related blood parameters were proportional to logged flight hours and not to age. Other authors, e.g., Biondi et al., have said the same" (pers. comm., Alves-Pereira, 2002). It is important to note that adverse health effects of exposure to low-frequency noise are evidently cumulative.

It has been suggested that DVT syndrome in airline passengers is merely a consequence of the last straw in a lifetime's exposure to low-frequency noise from all sources including ground transport and heavy industry (pers. comm., Alves-Pereira, 2002). As against this, people in their teens or 20s also develop air travel–related DVT syndrome; but this is the group now favouring high-powered sub-woofers in car audio systems as well as loud dance music with a strong low-frequency component at nightclubs.

Many years' exposure time is evidently not necessary for traveller's DVT syndrome, given the above information—remembering that some people develop small or "silent" blood clots after only one flight (Scurr et al., 2001), and also remembering what was shown by Bendz et al., i.e., an immediate physiological effect (tissue factor pathway activation) of an artificial or rapid air pressure decrease.

Infrasound is, in effect, a pulsed or repeated, barometrically rapid, "low/high" air pressure change or oscillation at a rate less than 20 times per second and hence inaudible.

OTHER ADVERSE EFFECTS OF INFRASOUND

Infrasound is, in effect, a pulsed or repeated, barometrically rapid, "low/high" air pressure change or oscillation at a rate less than 20 times per second and hence inaudible. It is reasonable to suppose that exposure to infrasound can also activate the human tissue factor pathway and thus the blood-clotting process, as clearly indicated in the medical research already referenced.

Infrasound is therefore proposed as the essential human health problem in aircraft, and is a common factor in all of the adverse health events discussed in this article and in the Eastern Bloc medical research mentioned previously.

Temporal lobe atrophy in female flight attendants has been reported by Cho (2001). He attributes it to jet lag. However, the neurological trauma he reports is apparently consistent with that reported by Castelo Branco et al. (1999) and attributed therein to occupational exposure to low-frequency noise. It is suggested that this syndrome relates essentially to prolonged exposure to infrasound/vibration in aircraft, and not to time zone confusion.

An excess of cases of pulmonary embolism (PE) during the London Blitz, discussed by Milne (1992), is therein attributed to immobility in cramped conditions. This has been seized upon by contemporary commentators to "explain" DVT syndrome in airline passengers and other travellers, but this ignores the air pressure wave(s), i.e., *overpressure*, from bomb explosions—a more likely primary cause of PE in light of the research collated in this article. Defence forces in Russia and Australia are now known to be interested in adverse health effects of exposure to overpressure from artillery.

I am not aware of any unambiguous medical evidence linking traveller's DVT solely with immobility. The "sitting down" or "immobility" theory is quite unconvincing, given that millions sit, squat or lie down all over the world, day after day, without ill effect—including office workers, individuals in old people's homes, people in a coma, etc. No doubt immobility is a contributing factor in certain individuals, as are, clearly, genetic factors. But those airline flight attendants who have reportedly suffered DVT (and temporal lobe atrophy) are relatively mobile compared with most passengers.

There is an association between age and increased incidence of non-specific DVT in the general population (which may well be due to longer-term exposure to low-frequency noise), but this does not seem to be so with traveller's DVT: a number of cases in young athletes have been reported. Divers—a group already stressed by relatively rapid air or water pressure changes—appear to be particularly vulnerable to this syndrome, too.

As for the "fear of flying" theory proposed in the UK in January 2002 by Peter Hughes of Hughes DVT Research (the inventor of compression stockings for air travellers) and receiving some publicity, this can be regarded as scraping the bottom of the barrel in an attempt to avoid the more obvious implications of sitting for extended periods of time in the midst of thunderous noise, even if transformed into inaudibility. Newton's second law of thermodynamics (conservation of energy) still applies; such energy is not magically removed.

INFRASOUND IN AIRCRAFT: THE EVIDENCE

1. The contrail (the evidence of our eyes). In atomic physics, a cloud chamber is used to detect and display the tracks of charged particles. Such a device is a minuscule copy of the sky above, in which we can all see that a jet plane leaves a contrail which is not linear but is like a regular string of beads in still air, or like a fishbone where there is a crosswind. This display is more or less affected by atmospheric turbulence, but the effect in still air is unmistakable and undeniable, insofar as it provides a graphic display of an infrasonic pulsation from the engines which can be timed visually at several pulses per second.

2. The acoustic frequency spectrum emitted by jet engines (the evidence of our ears). Our ears tell us it is a "thunderous" noise, also containing the shrill notes of higher frequencies. Thunder is low-frequency sound, extending well into the infrasonic (inaudible) frequency domain. Various papers have been published indicating just this, including Petrovic (1980), Kehoe et al. (1994), Baklanov (2000), Scholz (2000), Alves-Pereira et al. (2001) and Smith (2002).

The title of the Petrovic paper is apparently self-explanatory, though it was not available. Kehoe et al. describe NASA ground vibration tests on a *Jetstar* passenger aircraft and an FA-18 fighter jet which identified vibratory modes of basic structures such as wings and fuselage in the range of 5–18 Hz. If the fuselage of a passenger jet is flexing at 11 Hz, even at small amplitude, what is the effect on the passengers? Note that this frequency is close to the theoretical air pressure (infrasonic) resonance in an airplane fuselage of length 15 metres. The exact dimensions of the small-to medium-sized *Jetstar* airplanes are not known to this author.

Baklanov writes: "High limit of engine behaviour as a solid body is in the range 25–30 Hz for a number of *Tupolev* trunk-route jet aircraft. Disturbances in the engine gas flow duct are one source of noise." Scholz writes. "Exhaust systems are one of the most important noise sources in modern turbine power plants. In some cases acoustic resonance can occur, producing very high sound-pressure levels, usually at low frequencies."

Alves-Pereira et al. measured infrasound in pilots' cabins of commercial aircraft, this apparently being generated by airflow impact on leading edges of the airplane, especially at lower altitudes. Smith found low-frequency noise levels between 5 Hz and 250 Hz sufficient to resonate aircrew upper torsos in several military aircraft -and amplitudes were higher aft of the engine exhaust outlet.

3. Random vibration excitation. "Aircraft, missiles and rockets are subjected to random vibration excitation. This is due to the extreme turbulence of jet exhaust downstream of the jet and rocket engines, and aerodynamic buffeting," according to remarks on the Aircraft Design Inc. website in 2001.

The aircraft's engines are connected to a resonant acoustic chamber, the passenger compartment, whose physical dimensions imply an infrasonic (inaudible) resonance, but in which items such as loose plastic window blinds may rattle.

PROPOSED MECHANISM: Infrasonic Resonance of Passenger Compartment

The aircraft's engines are connected to a resonant acoustic chamber, the passenger compartment, whose physical dimensions imply an infrasonic (inaudible) resonance, but in which items such as loose plastic window blinds may rattle.

An attached or coupled source of noise/vibration at 5–250 Hz is perfectly capable of resonating a large enclosure at an inaudible frequency—for example, 6–8 Hz. An air-filled cylinder of 30 metres in length resonates at around 6 Hz, in theory, like a giant organ pipe; lesser lengths resonate at higher frequencies.

Acoustic resonance has a considerable amplifying effect on the noise/vibration source. Noise/vibration was reportedly sufficiently intense in early jet planes as to cause structural failure.

Apart from the evidence enumerated above, especially Smith (2002), data on infrasound in jet planes appears to be scarce or unavailable. It is, of course, true that there has been no general requirement to measure infrasound in aircraft to date, given an exclusive regulatory focus on audible sound above 20 Hz in frequency. Infrasound was apparently not found at significant levels in passenger compartments of commercial jet planes by Alves-Pereira et al. (2001), suggesting no compartment resonance. However, these measurements were not continuous, thus intermittent air pressure oscillation of significant amplitude may simply have been missed. Perhaps these non-resonant levels are sufficient to account for the three syndromes in airline passengers and crew mentioned in this article; alternatively, compartment resonance may be intermittent. The Swedish Defence Materiel Administration collected references in 1985–86 which are said to include papers on infrasound in airplanes; this collection was not available to the author.

It is suggested that the phenomenon of passenger compartment infrasonic resonance, if present, may be *intermittent*, perhaps dependent on particular engine speed or atmospheric conditions. This is consistent with findings by Winck et al. (2002) of an average 3.1 "rapid dips" in blood oxygen levels of up to 10 per cent in airline passengers on long flights. In short flights, blood oxygen levels fell by only three per cent. This suggests a cumulative response in the longer flights, presumably not explained by reduced static cabin air pressure or quality.

Findings mentioned previously of hypercoagulability in pilots proportional to logged flight hours also indicate a cumulative effect, in that case of infrasound from air impact on aircraft leading edges.

As already demonstrated by Bendz et al., there is an immediate effect on blood chemistry of exposure to an air pressure decrease. It is suggested that infrasound exposure has the same effect; also, adverse health effects of exposure to infrasound are believed to be cumulative.

Winck et al. apparently did not measure air pressure or related changes during the flights in question, though decreased cabin air pressure in airplanes is mentioned as the reason for their research. Significantly, they did find different blood oxygen levels when people were tested in different parts of the airplane, e.g., the toilets, which would have similar static air pressure, suggesting that some other factor is involved, perhaps air pressure oscillation at different rates, amplitudes or times related to dimensional or other characteristics of the space or enclosure. Rapid "dips" in blood oxygen levels were not found at ground level (personal communication, Winck, 2002).

The French company ONERA is researching aircraft cabin noise generated by vibration from attached jet engines, but with an apparent focus on audible noise above 20 Hz. There is currently an ongoing international effort to quieten passenger jet planes, including a focus on infrasonic engine noise at NASA (e.g., the Advanced Subsonic Technology Noise Reduction Program). These efforts appear to have achieved not much more than a 3 dB reduction in low-frequency noise to date. There is obvious low-frequency vibration at take-off and landing, caused by low-altitude turbulence and/or contact with the runway. But inaudible air pressure waves or vibrations are here suggested to be present (constantly or intermittently) at cruising speed and altitude, and generated primarily from the engines.

RESEARCH RECOMMENDATIONS

In light of the information presented here, an extensive survey of infrasound in passenger jet planes is the obvious thing to do next, as a low-cost priority. Measurements should be taken over the entire flight of various models (and ages) of passenger jet planes, including at take-off and landing. Professional infrasound meters are now commercially available and these, together with laptop computers, are all that is required.

These measurements should be *unweighted*, given that at 25 Hz the dB(A) weighting required by existing noise legislation underrates the acoustic energy at this frequency by approximately 43 dB, or more than 99 per cent. At infrasonic frequencies below 20 Hz, the dB(A) weighting required by existing legislation can result in an indication of much less than one per cent of the actual energy present!

It seems that many people are not aware of this fact as it applies to sound and infrasound level measurement: the situation has arisen due to the erroneous belief that noise impacts only on the ear and hearing, thus the legislation has been tailored exactly to its acoustic response. However, the response of the human ear is but a small window into the total range of acoustic energies.

Human body resonance has been proposed to explain the potentially lethal effect of high-amplitude infrasound when used as a weapon.

INFRASOUND WEAPONRY AND DEFENCE

Human body resonance has been proposed to explain the potentially lethal effect of high-amplitude infrasound when used as a weapon. In Smith's work we have a strong indication that infrasound is potentially lethal, if this were needed in a situation where at least one US manufacturer (American Technology Corporation in association with Bath Iron Works) has announced (as at April 10, 2002) a contract for an acoustic weapon.

Some years ago, an article in *New Scientist* magazine described the *modus operandi* of an acoustic crowd-control device as initiating epileptic fits in members of the crowd. This is consistent with VAD findings and with other evidence. It may be that some information on adverse health effects of exposure to infrasound is presently classified.

Shurygin et al. (1975) have evidently investigated a specific effect of vibration and noise on military *matériel* squads of the Russian Army. Petrovic (1981) apparently investigated infrasound and ultrasound in vehicles of the Yugoslav Army. Smith (2002) evidently worked with US aircraft and personnel.

The Russian Army is apparently researching adverse health effects of exposure to overpressure from artillery (Belov, 2000). The Australian Army now has an interest in adverse occupational health effects of low-frequency noise or overpressure exposure (personal. communication with Lt Colonel Nick Rowntree, 2002).

According to acoustic engineer Sean Moch, who has worked with the Royal Air Force on a contract basis: "There has been a large amount of work on effects of infrasound done by the MoD in the UK, especially with regard to ground-operating personnel in the RAF who have to work near afterburning aircraft which have a phenomenal amount of infrasound. I have seen lead suits for aircrew which didn't look very comfortable" (personal communication, 2001).

We may ask: if the RAF requires its aircrew to be protected by lead suits, what is the risk for commercial jet plane crew and passengers, even without afterburners?

Commercial aircraft are lined with soundproofing material, evidently effective against entry of acoustic noise frequencies from the engines. But such materials cannot prevent the entry of lower-frequency, longer-wavelength noise, especially inaudible infrasound. Jet engines of commercial aircraft are already covered with lead or lead composite shielding to limit low-frequency noise transmission. The logical next step of lining the passenger cabin with lead shielding has obvious limitations in an aircraft.

It is known that some new metal-impregnated materials have been designed to absorb infrasound; a team at the University of Hong Kong has done such work. Lead or lead composite acoustic shielding has been used around jet engines for many years—but you cannot enclose the inlet or the exhaust outlet.

The US Office of Naval Research (an aviation centre) at Pensacola, Florida, is developing acoustic materials to attenuate low-frequency noise. In fact, they have managed a 30 dB attenuation at 80 Hz (pers. comm., Alves-Pereira, 2002). It is not known if this material is suitable for use in aircraft or if it is effective against infrasound, which by definition is below 20 Hz.

INFRASOUND IN OTHER TRANSPORT MODES

Submarines are also large acoustic chambers as are surface ships enclosing various large chambers.

Railway trains and buses also consist of large acoustic chambers, and with windows open would generate an infrasonic Helmholtz chamber resonance of significant amplitude. Inhabitants of buildings near to railway lines are said to feel upper body vibration when a train passes. In some metropolitan buses, the large side trim panels flap visibly at a low frequency, especially when the engine is labouring in "Drive" while stopped at a traffic light. Travel on these buses has typically led to an epileptic fit in one susceptible individual (pers. comm. with carer/healer Dawn Morgan, 2002).

In motor cars, there is a "buffeting" effect at speed with a window open; and infrasound at a level of 90 dB has been measured in a car at cruising speed with windows closed (pers. comm., Alves-Pereira, 2002).

The Royal Automobile Club of the UK announced in August 2002 that some drivers are susceptible to DVT syndrome, in particular those already at higher risk due to age, pregnancy, etc., and those driving for more than four hours at a stretch.

OUR CHOICE FOR THE FUTURE

There is little doubt in my mind that passenger jet planes, including proposed supersonic models, are already obsolete due to their inherent and unavoidable—if not presently appreciated or advertised—health hazards.

In Tofflerian Third Wave terms, it is surely significant that there is now increased manufacturing activity in the area of dirigibles (which do not use the jet engine), presently for transport of goods and as aerial cranes. They used to carry passengers regularly across the Atlantic and the *Graf Zeppelin* circumnavigated the world in 1929, covering 22,000 miles in just over 20 days with 20 passengers, mail and freight. The 1937 *Hindenburg* disaster, so called, was apparently due at least in part to the unknown use of an inflammable fabric-doping compound rather than to the flammability of hydrogen. There is some evidence of sabotage via an incendiary device; arrival in the USA was delayed by headwinds and all would otherwise have disembarked safely. With hindsight, we can also see that the choice of airplanes over dirigibles was driven by military requirements rather than the desires or needs of passengers. The experience of air travel by dirigible was one of stability and safety prior to 1937: you could shower and sleep on board in comfort unimaginable to today's jet passengers.

There is little doubt in my mind that passenger jet planes, including proposed supersonic models, are already obsolete due to their inherent and unavoidable—if not presently appreciated or advertised—health hazards.

The NASA vision for the future of aviation outlined in a statement given to the US House of Representatives on 7 March 2002 is one in which the gas turbine engine is replaced by fuel cells (presumably with electric motors), and the only sound is that of "air flowing over the fuselage". Unfortunately, even this solution would not remove infrasound in pilots' cabins generated by airflow impact on leading edges.

There is a clear choice facing responsible individuals and authorities: summon the courage to face this issue and deal with it now, or continue to avoid it and risk even larger compensation claims and financial disruption in future, more importantly with unnecessary fatalities—possibly including one's own. ∞

About the Author:

David Collier, BSc, DCH, is a retired stored products entomologist and science administrator; a sometime clinical hypnotherapist, specialised kinesiologist, counsellor and practitioner of *qi gong* and *sahaja* yoga; and now a medium for spiritual healing and chakra surgery. Many years ago he cured himself of a supposedly "incurable" autoimmune disease.

He is the inventor of the Extraphone, a device which extends human hearing into infrasonic and ultrasonic frequency domains, and is focus/facilitator for The Sanctuary, a community and centre for world peace, healing and sustainable technologies to be established near Canberra, Australia.

He is presently looking for start-up capital for the electronics manufacturing and marketing business which is to underwrite The Sanctuary. David Collier can be contacted c/- GPO Box 1755, Canberra, ACT 2600, Australia, or via email at dc888@tpg.com.au.

Author's Notes:

- This article is not a comprehensive scientific review, given that many papers were not available for detailed study, and methodology was not examined in detail. It is intended to summarise the more significant available evidence around this issue, albeit circumstantial in some cases. It is also intended to assist responsible parties to examine the issue properly and then deal with it for the greater good of all.
- This article has evolved over time to explain matters in more detail and to include recommendations for particular action, given apparent widespread difficulty in comprehending the issue and in knowing what steps to take to deal with it.
- An officer of the International Civil Aviation Organisation has now submitted a version of this article to the Scientific Executive Committee of the WHO/ICAO WRIGHT Project (see Anon., 2002).

Acknowledgments:

Thanks to Spirit and those "in Spirit" for enabling me to contribute in this area. Thanks to my friends for providing homes, food, Internet access and moral support. Thanks to the few who responded to requests for information with enthusiasm and encouragement; also thanks to the many experts, authorities and politicians here and overseas whose notable and continued silence on this issue confirm its importance.

References

- Alves-Pereira, M. and Castelo Branco, Nuno (2000). Vibroacoustic disease: the need for a new attitude towards noise. CITIDEP and DCEA-FCT-UNL, Portugal.
- Alves-Pereira et al. (2001). Airflow-Induced Infrasound in Commercial Aircraft. Internoise 2001 Conference. The Hague, Holland. August 2001:1011-14.
- Anon. (2002). The WRIGHT Project on Air Travel and Venous Thromboembolism. WHO/ICAO.
- Baklanov, V. (2000). Investigation of contribution of power plant effect to vibroacoustic field of pressurised aircraft cabin. Internoise 2000 submitted paper IN2000/958.
- Belov, A.V. (2000). Effect of a noise of military engineering on psychophysiological condition of the servicemen. Invited paper, 10th session of the Russian Acoustical Society, Kazan Military Artillery School.
- Bendz, B. et al. (1999). Effect of hypobaric hypoxia on tissue factor induced coagulation. *Thrombosis & Hemostasis.* ISTH Congress, Washington.
- Castelo Branco et al. (1999). Vibroacoustic disease. *Aviation, Space and Environmental Medicine* (*ASEM*) 70(3), Section II, Supplement, March 1999.
- Cho, K. (2001). Chronic 'jet lag' produces temporal lobe atrophy and spatial cognitive deficits. *Nature Neuroscience* 4:567-568, June 2001.
- Cucinell, S.A., Pitts, C.M. (1987). Thrombosis at mountain altitudes. *ASEM* 58:1109-11.
- Gabovich, R.D. (1979). Effect of infrasound on bioenergetics processes, organ ultrastructural organisation and on regulation processes. *Gig. Tr. Prof. Zabol.*
- Kehoe, Michael W., Freudlinger, Lawrence C. (1994). Aircraft Ground Vibration Testing at the NASA Dryden Research Facility – 1993.

Continued on page 75

Continued from page 38

NASA Technical Memorandum TM-104275.
• Kesteven, P.J.L. and Robinson, B. (2000). Traveller's Thrombosis. *Thorax* 55(Suppl.1):S32-S36.
• Michailova, L.V. (1971). Effect of noise of various parameters on blood coagulation in experimental animals. *Gig. Sanit.* 36(11):111-112.
• Milne, R. (1992). Venous thromboembolism and travel: is there an association? *J. R. Coll. Physicians Lond.* 26(1):47-49.
• Mooney, Michael M. (1974). *The Hindenburg*. Mayflower Books Ltd.
• Nekhoroshev, A.S and Glinchikov, V.V. (1992). Morphological research on liver structures of experimental animals under the action of infrasound. *Aviakosm. Ekolog. Med.* 26(3):56-58.
• Petrovic, D. (1980). Ultrasound and infrasound in pilot's cabins in commercial aircraft. *Vojnosanit. Pregl.*
• Petrovic, D. (1981). Infrasound, ultrasound and noise in combat and non-combat vehicles of the Yugoslav Army. *Vojnosanit. Pregl.*
• Polanowska, R. and Cierniewski, C.S. (1987). Activation of blood platelets and increased plasma fibrinogen and fibronectin in men exposed to infrasounds, acoustic noise and airborne dust in electric steelworks. *Thromb. Res.* 48(3):363-371.
• Poponick, J., and Bosker, G. (2002). The Current Challenge of Venous Thromboembolism (VTE) in the Hospitalised Patient: Optimising Recognition, Evaluation, and Prophylaxis of Deep Venous Thrombosis (DVT) and Pulmonary Embolism (PE). Part 1: Patient Identification, Risk Factor Assessment, and Diagnostic Strategies. *Hospital Medicine Consensus Reports* July 2002 (14 pp.).
• Scholz, U. (2000). Measurement method for the low frequency acoustical behaviour inside the exhaust system of a combustion turbine. Internoise 2000 submitted paper IN2000/925.
• Scurr, J.H. et al. (2001). Frequency and prevention of symptomless deep-vein thrombosis in long-haul flights: a randomised trial. *Lancet* 357:1485-89.
• Serikova, A.Z., Viazitskii, P.O., Porokhnia, N.P. (1977). Effect of general low-frequency vibration on the functional state of the blood coagulation system. *Voen. Med. Zh.* (9):58.
• Shurygin, D., Viazitskii, P.O., Kudrin, I.D. (1975). Effect of vibration and noise on the function of the endocrine glands in military materiel squads. *Voen. Med. Zh.* (10):50-52.
• Silva, M.J., Carothers, A., Castelo Branco, M.S.N.A.A., Castelo Branco, N.A.A. (1996). Sister chromatid exchanges in workers exposed to noise and vibration. *Mutation Research* 369:113-121.
• Smith, S.D. (2002). Characterising the Effects of Airborne Vibration on Human Body Vibration Response. *ASEM* 73:36-45.
• Song, S.Y. et al. (1986). Cerebral thrombosis at altitude: its pathogenesis and the problems of prevention and treatment. *ASEM* 57:71-6.
• Steinhauser, R.P. and Stewart, J.C. (1989). Deep venous thrombosis in the military pilot. *ASEM* 60:1096-8.
• Stepanian, R.S., Airapetian, G.S., Markarian, G.F., Airapetian, S.N., Arakelian, G.A. (2000). The action of infrasound oscillations on the properties of water and of a DNA solution. *Radiats. Biol. Radioecol.* July-Aug 40(4):435-8 (in Russian).
• Svidovyi, V.I., Kolmakov, V.N., Kuznetsova, G.V. (1985). Changes in the aminotransferase activity and erythrocyte membrane permeability in exposure to infrasound and low-frequency noise. *Gig. Sanit.* (10):73-74.
• Swedish Defence Materiel Administration (FMV) (1985–86). Infrasound, a summary of interesting articles, FMV *Electro* A12:142, May 1985, 252 pp.; Infrasound, a bibliography of articles up to April 1983, FMV *Electro* A12:140, May 1985, ca. 500 pp; Infrasound, a supplementary bibliography of articles, May 1983–October 1985, FMV *Electro* A12:17691/86, June 1986, ca. 200 pp.
• Tropnikova, G.K. (1990). The effect of whole-body low-frequency vibration and noise on the serotonin content of the blood and plasma. *Gig. Sanit.* (10):60-62.
• Vasilev, Alu (1999). Modern diagnostic approaches to investigations of abdominal aorta changes in flying personnel. *Aviakosm. Ekolog. Med.* 33(1):48-50.
• Winck, J.C., Drummond, M., Morais, A., Almeida, J., Marques, J.A. (2002). In-flight oxygen desaturation in healthy subjects – evaluation by pulse oximetry. European Respiratory Society 12th Annual Congress.